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Modelling the distribution of ice at Lyot crater, Mars

Lori-Ann Foley, Matt Balme, Stephen Lewis

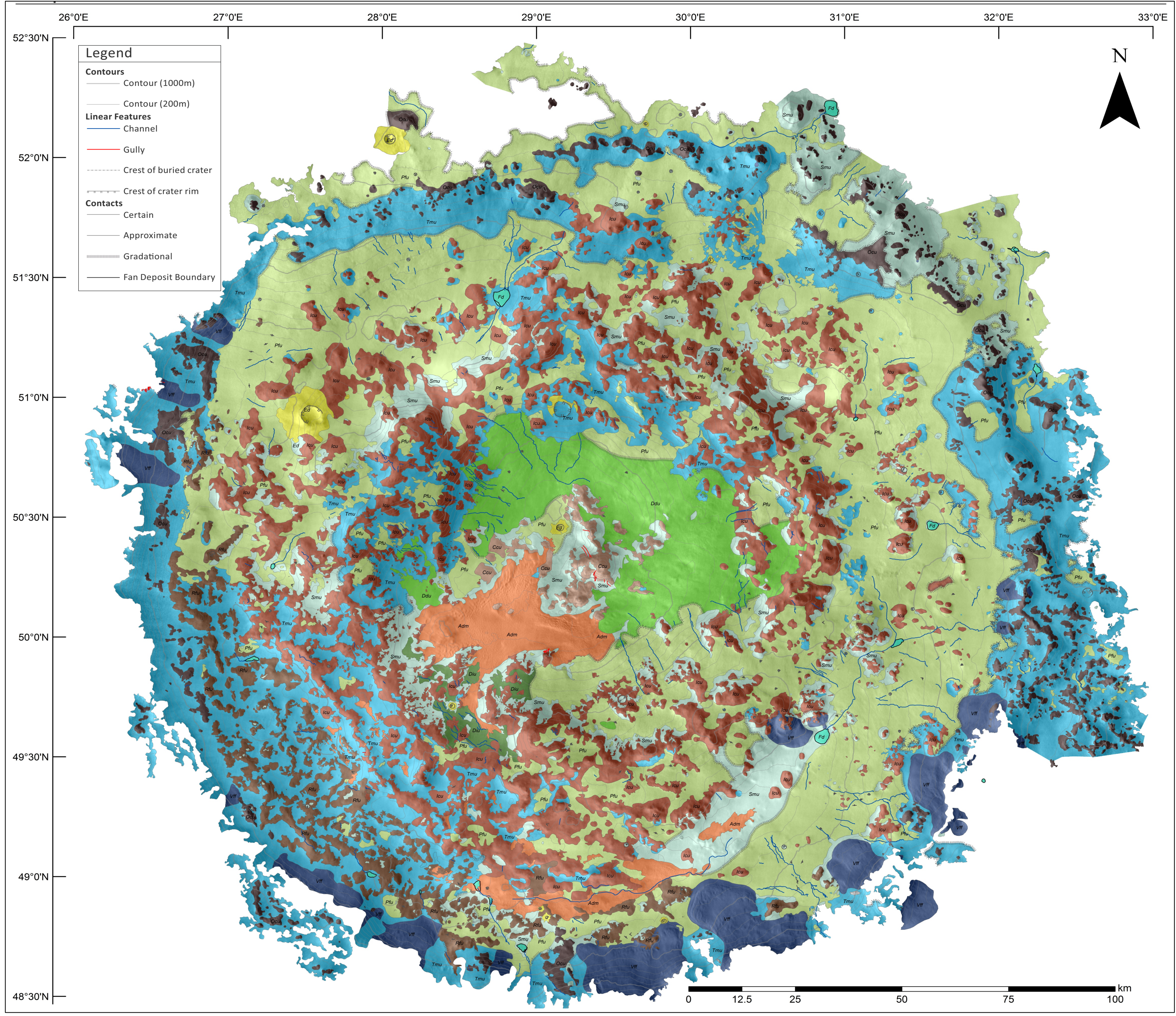
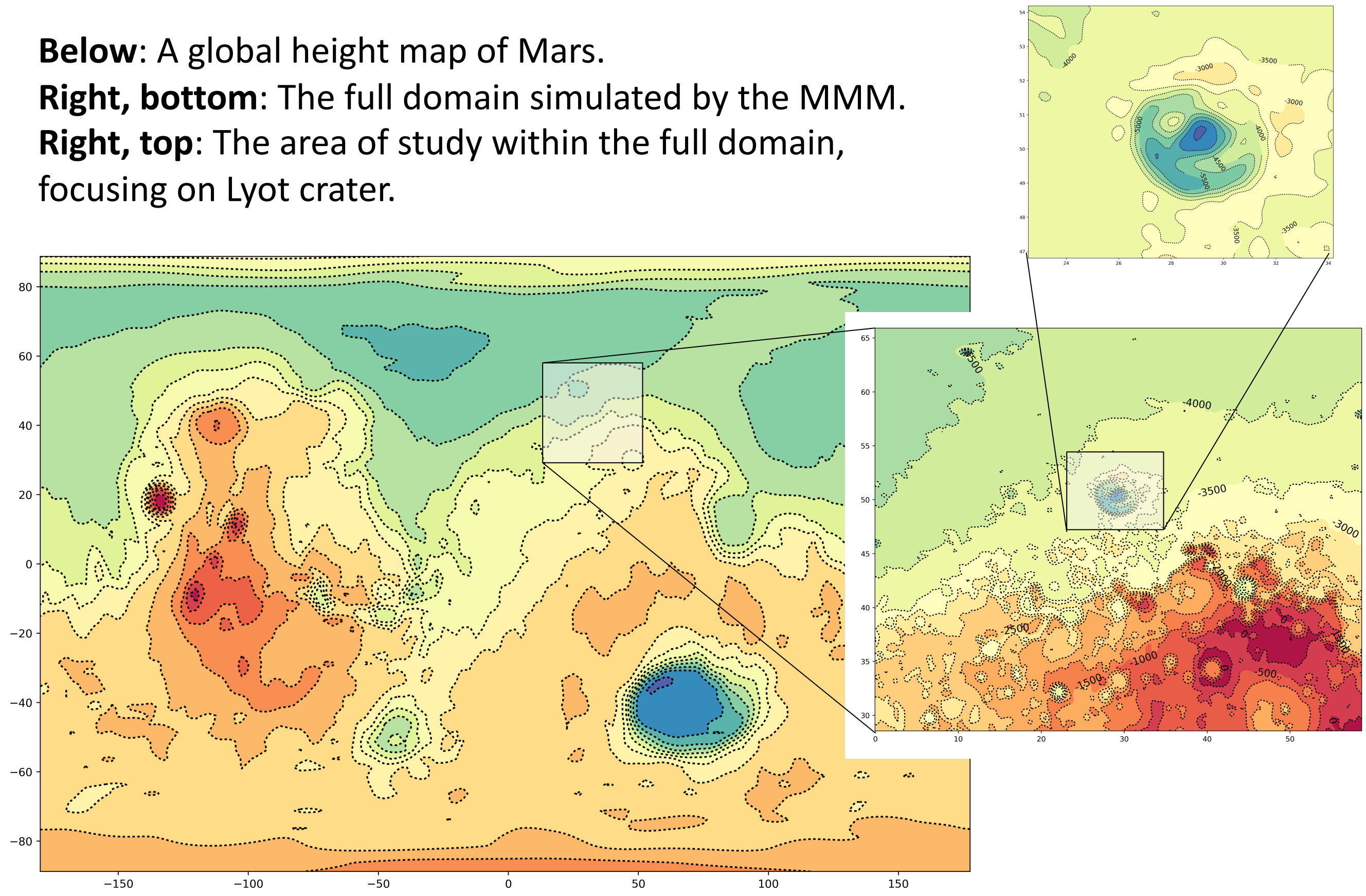
Introduction

- The water cycle is a crucial element of the Martian climate, past and present, and has significant effects on the geology.^{1,2,3,4}
- The climate changes as variations in orbital parameters such as obliquity, eccentricity and perihelion change.^{3,5}
- Lyot crater is a site of interest due to its large size (~215 km diameter)⁶, its relatively young age (1.4-3.4 Gyr)^{7,8} and its low elevation giving rise to a higher surface pressure than the surrounding landscape (the crater floor is ~3000m below the plains)^{9,10,11}.
- Using the LMD-UK Mars Mesoscale Climate Model centred on Lyot crater, experiments are being conducted to study the relationship over time between the local water cycle and the ice-rich deposits in and around the crater.

Below: A global height map of Mars.

Right, bottom: The full domain simulated by the MMM.

Right, top: The area of study within the full domain, focusing on Lyot crater.



Above: A geomorphological map of present-day Lyot crater, produced by Laura Brooker. Mantle unit areas (blue) and pitted unit areas (green) show the most evidence of past aqueous/ice-melt activity; the stratigraphic units are described in detail in 12. **Right:** Figures using data from the MMM, showing the mean surface water ice over five days at the spring equinox ($L_s = 03 - 08$) (note the change of scale). The contours show terrain height. Output from the MMM is compared to the Brooker map to assess the impact of climate change on the geology at different epochs.

Conclusions

- The movement of surface water ice around the planet changes with obliquity. Output from the MMM shows that the amount of ice at Lyot crater increases and decreases over time, impacting on the geology.
- Future work will include simulations varying eccentricity and perihelion.

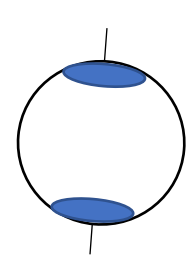
LMD-UK Mars Mesoscale Model (MMM)¹³

- Climate model simulations centred on Lyot crater using a representative set of orbital parameters can provide insight into the processes which control the distribution of ice.^{14,15}
- Simulations with obliquities of 5° – 55° were run, with ice sources at one pole, both poles or in the tropics.
- The MMM's water cycle package, modelling the behaviour of water vapour and ice, was included.
- Output focused on where water vapour is generated, how it is transported and where it is deposited as ice.

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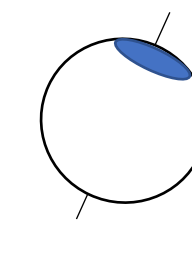
Results



Obliquity: 5°

Ice source: both poles

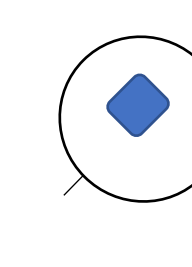
The poles receive very little solar insolation, only small amounts of water vapour sublimate from these ice sources and the majority of the ice can be found at the poles.^{2,3} During these periods Lyot crater has little or no surface water ice.



Obliquity: 25°

Ice source:
north pole

The ice source at the north pole receives more solar insolation, more water vapour sublimates into the atmosphere and is transported south,^{2,3} some condensing in craters such as Lyot. MMM output (right) shows ice in the deepest parts of the crater, areas where today ice has been mapped (left) – the light blue areas are ice-rich mantling material deposited by air fall.¹²



Obliquity: 45°

Ice source:
tropics

The poles receive more insolation, much of their ice caps sublimate and the water vapour condenses in the tropics.^{2,3} MMM output (right) shows ice where today no ice is mapped – the green areas (left) show where pitted units have been created when ice deposited in earlier epochs has sublimated under more recent climate conditions.¹²

